National Aeronautics and Space Administration
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ST — IM — 10360

ON THE POSSIBILITY OF DETERMINATION OF THE S-INDEX FROM THE DISTRIBUTION OF UNSTEADY METEOR RADIOECHO DURATIONS

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22 JULY 1965

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Astronomicheskiy Zhurnal
Tom 42, vyp. 3, 656-659
Izdatel'stvo "NAUKA", 1965

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SUMMARY

A method is described for the determination of the mass distribution law of meteoric bodies from the distribution of radioecho durations when the latter originate from noncondensed meteor trails.

This method is applied for the determination of the s-index of the faint meteors of the Geminides in 1963.

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1. Statement of the Problem. Bases of the Method.

It is customary to utilize the amplitude distribution of meteor radioechoes originating from noncondensed meteor trails for the determination of the index s, characterizing the distribution of meteor bodies by masses in the region of small masses [1, 2].

At the same time the index s may be also found from the distribution of the durations of unsteady (or exponential) radioechoes, that is of reflections from noncondensed trails with linear electron density $\alpha \leqslant 2.4 \cdot 10^{12}$ electron/cm [1].

Such a possibility was noted earlier [3].

A simplified method for determining the s - index consists in the following. If we assume that the statistical characteristics of unsteady

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* O VOZMOZHNOSTI OPREDELENIYA POKAZATELYA S PO RASPREDELENIYU DLITEL'NOSTEY NEUSTOYCHIVYKH METEORNYKH RADIOEKHO

radioechoes are mainly determined by the properties of reflections arriving from a thin layer, lying in the region of characteristic height h_m, the integral law of duration distribution (above noise level) will be approximately [3] :

$$N(\tau) \sim e^{-(4\pi/\lambda)^2(s-1)D\tau}, \qquad (1)$$

where D is the diffusion coefficient and λ is the wavelength.

Therefore, the s- index will be approximately

$$s = 1 + \frac{A}{D}, \qquad (2)$$

where

$$A = \frac{\lambda^2}{16\pi^2} \cdot \frac{\ln N_1 - \ln N_2}{\tau_2 - \tau_1}; \qquad (3)$$

Here N_1 (N_2) is the number of reflections (of unsteady type) with a duration $\geqslant \tau_1(\tau_2)$. Formula (2) would have been accurate, had the outlined layer been so thin, that we could estimate D = const (and, moreover, the initial radius $r_o = 0$, with the radioechoes originating from an area lying in the echo plane, at $h = h_m$).

Thus, for the determination of the s-index it is necessary to plot the distribution of unsteady type meteor radioechoes by the duration and, knowing λ, find the quantity A (3); moreover, it is necessary to know the diffusion coefficient D. It is quite evident that if sorting of reflections by heights were even made, and only radioechoes, having arrived from a narrow band adjacent to the characteristic height, were separated from the aggregate of reflections, there would be a certain scatter of the quantity D. Indeed, the diffusion coefficient D must vary quite notably in the range of heights, in which the electron density α remains close to α_m, that is the electron density at the characteristic height h_m, (see Fig. 1). Obviously, when investigating this question strictly, the inconstancy of D should be taken into account at the outset in the region $h \approx h_m$, and this should be reflected in the distribution of durations (1). However, in the approximate approach, not accounting for the reception of the entire echo plane, we may postulate $D \approx \overline{D}$, and thus :

$$s = 1 + \frac{A}{\overline{D}}. \qquad (4)$$

Another method of determination of s, taking into account the inconstancy of D, consists in the following. Assume that the differential law of distribution of the diffusion coefficient D would be p(D). The probability density p(s) would then be determined from

$$p(s) = p_D(D)\left|\frac{dD}{ds}\right|, \tag{5}$$

and, as may be easily seen,

$$p(s) = p_D(D)\frac{A}{(s-1)^2}. \tag{6}$$

Knowing p(s), we shall find the mean value of the index s:

$$\bar{s} = \int_0^\infty sp(s)\,ds. \tag{7}$$

Let us illustrate the description of the method for finding s using for example the Geminides stream.

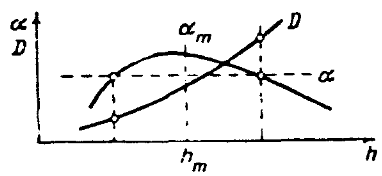


Fig. 1

Variation of α and D with height (illustrations)

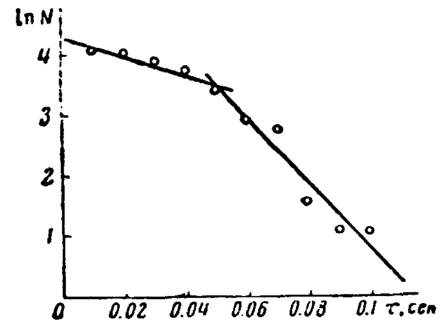


Fig. 2

Distribution (integral) of unsteady-types meteor radio-echoes by duration (Geminides night from 13 to 14 Dec. 1963) N is the number of reflections with duration $\geqslant \tau$ sec.

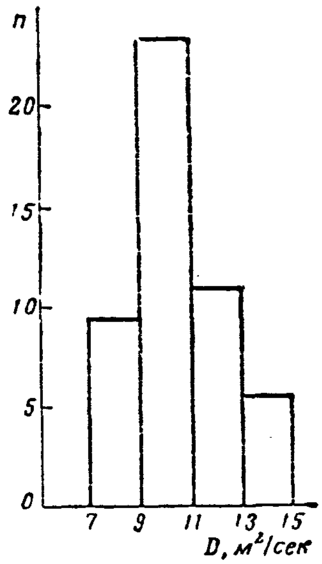
2. - Example of Determination of s from the Distribution of Unsteady Radioechoes

61 exponential-type reflections were fixed in about 30 minutes during the night from 13 to 14 December 1963 (parameters of the Kiyev State University: $\lambda = 9.59$ m, $P_u \approx 20$ kw; antennas — weakly-directed at $h \approx \lambda/2$ above ground; $F_u = 500$ pulse/sec, every fifth being "double"; scan duration 0.11 sec). Plotted in Fig. 2 is the distribution of the diffusion coefficients ($\bar{D} \approx 10.4$ m / sec [4]. As follows from [4], $s \approx 4$ for the region $\tau \approx 0.05 - 0.01$ sec.

Another method (see (7)) allowed to obtain for the same interval τ the differential distribution of p(s) at first (6) (Fig. 4), and then find $\bar{s}$ (7), which was found to be $\bar{s} \approx 4.1$.

In the region of lesser durations ($\tau \approx 0.01 \div 0.05$ sec) $s \approx 1.9$ (4).

Such a discrepancy in the value of s for intervals $\tau \approx 0.05 \div 0.1$ sec and $\tau \approx 0.01 \div 0.05$ sec is apparently explained by the fact, that as the mass decreases, the number of meteors accrues sharply at the beginning, and then at a slower pace. But, at the same time, it should be taken



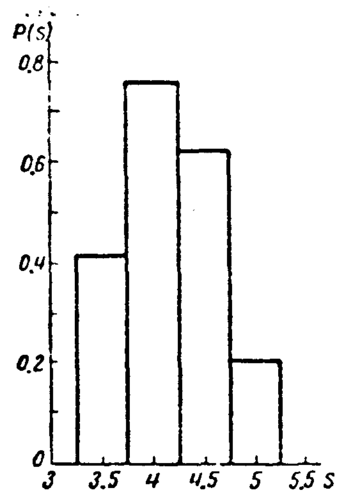


Fig. 3. - Differential distribution of diffusion coefficients obtained by unsteady-type trails (for the same time as the distribution in Fig. 2); n is the number of measurements having given the value of the diffusion coefficient D m^2/sec in the given interval ΔD.

Fig. 4. - Differential distribution of the index s.

into account, that the unsteady type reflections of very short duration are detected by the apparatus "at limit" of its possibilities, and that is why the result obtained for $\tau \approx 0.01 \div 0.05$ sec cannot be estimated to be reliable (apparatus of higher sensitivity would be required).

As to the fact that in the region $\tau \approx 0.05 \div 0.1$ sec the index s was obtained quite great (it is well known from observations of steady trails, that $s \approx 1.35 \div 2.49$ [5]), it should be taken into account that between 13 and 15 December a sharp increase of the number of meteors with +5 stellar magnitude was noted in the Geminides stream [6].

3. - CONCLUSIONS.

Two simplified methods of index s determination are proposed, starting from the distribution of unsteady meteor radioecho durations.

A value $s \approx 4$ (at $\lambda \approx 9.6$ m) was obtained in the 1963 Geminides epoch during the night from 13 to 14 December for the region $\tau \approx 0.05 \div 0.1$ sec.

The author expresses his gratitude to fellow I. V. Bayrachenko for submitting the results of observations at $\lambda = 9.59$ m and to fellow Yu. V. Chumak for his help in completing the calculations.

*** THE END ***

Kiyev State University Received on 4 August 1964

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